Dilutions Tutorial

Adapted from ccbcmd.edu

$$M_1V_1 = M_2V_2$$

Knowing how to solve "dilution problems" is immensely important for students in chemistry, biology and related fields. Often you will encounter these kinds of problems in future science courses as well as in future place of employment (in biology labs, in pharmacy school, in nursing school, etc.) For example, you may be asked to prepare a solution of a particular concentration, starting with a more concentrated solution, or you may be asked what the concentration of a solution is if you added a known amount of water to a given solution.

First, let us think about what "dilution" means. The process of dilution involves starting with a solution of a particular concentration and adding more solvent. In this tutorial we will focus on aqueous solutions, so the solvent would be water.

It is important to realize in dilution what gets changed and what does NOT get changed. Obviously when we add more water, the total volume is increased and the concentration is decreased. Now, think carefully what is NOT changed…… The answer is the solute is unchanged. There is no chemical reaction involved, so we still have the same solute. Also, the amount (# of moles and # of grams) of the solute is unchanged. This is an important point.

Before we proceed, it is important to remember that a solution labeled "6M" means 6 moles solute/L solution. The units of molarity are mol/L.

Now, if we multiply M with V (in units of L), the units tell us we would get moles:
M x V = mol/L x L = mol
You should commit this to memory before proceeding with this tutorial because you will often need to calculate the moles of solute for various problems.

EXAMPLES OF DILUTION PROBLEM

Example 1
Let us consider 5.00 mL of a solution labeled "6.00 M HCl" and we now add enough water to give a total volume of 14.00 mL. What is the concentration of the new solution?

Strategy: Think of this as involving **two** conditions: Condition 1 for the original solution (with M_1 and V_1) and Condition 2 for the final solution (with M_2 and V_2). For Condition 1, the # mol HCl = M_1V_1 and for Condition 2, the # mol HCl = M_2V_2.

Remember that the # mol of HCl is unchanged, so $M_1V_1 = M_2V_2$. This is the equation we will apply to all "dilution problems." It also applies to situations where the concentration is increased (by evaporating off some of the water). ***It is important to note that this equation should be used ONLY where there is no chemical reaction (no change in the amount of solute).***

Example 2:
How would you prepare 25 mL of 0.010M NaCl starting with a 0.500 M NaCl solution?

Solution:

Is this a "dilution problem?" Ans. Yes

M_1 = 0.010 M $\quad$ M_2 = 0.500 M

V_1 = 25 mL → 0.025L $\quad$ V_2 = ?

(Note: It doesn't matter whether you assign the <u>final condition</u> or the <u>initial condition</u> as Condition 1, as long as you are consistent. For example, you should be careful <u>not</u> to assign M_1 to the final condition and V_1 to the initial condition! Here, in this example, I happen to assign the <u>final</u> condition as Condition 1.)

$M_1V_1 = M_2V_2$

$$V_2 = \frac{M_1V_1}{M_2} = \frac{(0.010M)(0.025L)}{0.500M} = 0.05L \text{ or } 50mL$$

Example 3:

Describe how you would prepare 2.00 L of 0.100 M K_2CrO_4 from 1.75 M K_2CrO_4 stock solution.

1. Use the dilution formula to calculate amount of concentrate needed (V_1) and amount of water needed to perform dilution:

$$V_1 = \frac{M_2V_2}{M_1} = \frac{(0.100M)(2.00L)}{1.75M} = 0.114L \text{ or } 114mL$$

2. *Add 114mL of concentrated K_2CrO_4 to a 2.0L volumetric flask and dilute with water to 2.0L mark, shake to mix*

Dilution Practice Problems

1. If Melissa dilute 75 mL of 0.50 M CaF_2 solution to a final volume of 375 mL, what will be the molarity of the resulting solution?

2. How much water will Luis need to add to 250 mL of 0.50 M CaF_2 solution to make a solution with a concentration of 0.30 M?

3. Explain how David would make 500 mL of a 0.15 M HCl solution if the only things available to me were a graduated cylinder, distilled water, and a very large bottle of 1.00 M HCl.

4. If Shelby has 340 mL of a 0.5 M NaBr solution, what will the concentration be if I add 560 mL more water to it?

5. If Raymond dilute 250 mL of 0.10 M lithium acetate ($LiC_2H_3O_2$) solution to a volume of 750 mL, what will the concentration of this solution be?

6. a: How many moles of lithium acetate (from #5) are in the 250 mL 0.1M original solution?
   b: How many moles of lithium acetate are in the final 750 mL solution?

7. If Alex leaves 750 mL of 0.50 M calcium chloride ($CaCl_2$) solution uncovered on a windowsill and 150 mL of the solvent evaporates, what will the new concentration of the calcium chloride solution be?

8. If the ratio of Ca^{2+} ion to $CaCl_2$ molecules is 1:1 or $\frac{1\ mol\ Ca^{2+}}{1mol\ CaCl_2}$
   a: what is ratio of Cl^- to $CaCl_2$?
   b: How many mole of Cl^- are in the final solution from question 7?

9. To what volume would Nico need to add water to the evaporated solution in problem 7 to get a solution with a concentration of 0.25 M?

10. Given 50.00 mL of concentrated nitric acid (16M HNO_3) is diluted to 1.000 L. What is the concentration of the new solution?

11. A solution is prepared by dissolving 10.8 g ammonium sulfate in enough water to make 100.0 mL stock solution. A 10.00-mL sample of this stock solution is then placed in a 50.00-mL volumetric flask and diluted to the mark with water. What is the molarity of the new solution?

12. We need a 0.60 M NaCl solution. Starting with 50.00 mL of 0.300 M NaCl, what must you do? (Assume there is no other source of NaCl available to you.)

13. When 3.0g of NaCl is made up to a 0.25L solution and added to a 0.5L 0.01M solution of $AgNO_3$:
    a. Write balanced equation showing soluble and insoluble (precipitate) for the rxn
    b. How many moles of NaCl and $AgNO_3$ are in the rxn?
    c. What is the limiting reagent?
    d. What is the concentration of the aqueous product (assume total volume to be 0.75L)?

Dilution Practice Problems Answers

1. **0.10 M** 2. **167 mL water** 3. **75mL of solution with 425 mL DI water** 4. **0.19 M** 5. **0.033 M**
6. a: **0.025mol $LiC_2H_3O_2$** b: **0.025mol $LiC_2H_3O_2$** 7. **0.625M**
8. a. **2:1** b:**0.75mol Cl^-** 9. **1500 mL** 10. **0.8M** 11. **0.164M $(NH_4)_2SO_4$**
12. 0.60 M is twice the concentration of the original solution. The 50.00 mL of the original solution needs to be ***concentrated down to half its volume***. So, we need to evaporate the solution down to approximately 25 mL. $M_1V_1 = M_2V_2$ where $M_1 = 0.300$ M, $V_1 = 50.00$ mL and $M_2 = 0.60$M
13. a. **NaCl (aq) + $AgNO_3$ (aq) → AgCl(s) + $NaNO_3$ (aq)** b. **0.0517mol NaCl and 0.005mol $AgNO_3$**
c. **$AgNO_3$** d. **0.0066 M $NaNO_3$**